

TLC5944EVM-358

This user's guide describes the characteristics, setup, and use of the TLC5944EVM-358 Evaluation Module (EVM). This EVM helps the user evaluate the features of the Texas Instruments TLC5944, which is a 16-channel, constant-current LED driver. This user's guide includes setup instructions, a schematic diagram, a bill of materials, printed-circuit board layout drawings, and software instructions.

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1 Introduction

The Texas Instruments TLC5944 is a 16-channel, constant-current LED driver that is capable of driving up to 60 mA per channel. The TLC5944 has several features including 6-bit Dot Correction, 12-bit grayscale PWM dimming, Pre-Charge FET, LED failure and overtemperature detection. For more information on PWM dimming, see the TLC5944 data sheet ([SBVS112](#)), a Dot Correction technical paper ([SLYT225](#)), and a PWM Dimming technical paper ([SLYT238](#)) on the TI Web site. This EVM contains three TLC5944 integrated circuits (IC) connected in series. The three ICs drive 16 light-emitting diodes (LED), each having a red, green, and blue LED in the same package.

Multiplexing, Ghosting, and Pre-Charge FETs

The EVM is also configured to demonstrate LED multiplexing, which is connecting more than one LED to an LED driver output. The EVM demonstrates multiplexing by connecting an additional row of red LEDs to one of the LED driver ICs. The practice of multiplexing LEDs often generates a phenomenon known as Ghosting. This phenomenon is also called Phantom Noise or Spike Noise. Ghosting occurs when an LED is programmed to be off, but is visually illuminated. The LED is illuminated because of stray currents flowing through it that are generated by switching the rows of LEDs in and out of the circuit, stray board capacitance, and mismatches in diode forward voltages. The TLC5944 contains Pre-Charge FETs that shunt these currents around the LEDs so they do not produce light. The EVM GUI software allows the user to easily demonstrate multiplexing both with and without the Pre-Charge FETs to see the ghosting effect.

1.1 Requirements

In order to operate this EVM, the following components must be connected and properly configured. All components, software, and connectors are supplied in the EVM except for the host computer and the dc power supply

1.1.1 Software

Texas Instruments provides a compact disk (CD) in the EVM kit that contains the software necessary to evaluate the TLC5944EVM. Check the TLC5944 product folder on the TI Web site (www.ti.com) for updates to the software.

1.1.2 Host Computer

A computer with a USB port is required to operate this EVM. The TLC5944 software runs on the personal computer (PC) and communicates with the EVM via the PC's USB port.

PC Requirements:

- Windows™ 2000 or Windows XP operating system
- USB port
- Minimum of 30 MB of free hard disk space (100 MB recommended)
- Minimum of 256 MB of RAM

1.1.3 Power Supply Requirements

A dc power supply capable of delivering 5 V at 1 A is required to power the EVM.

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Windows, Internet Explorer are trademarks of Microsoft Corporation.
VeriSign is a trademark of VeriSign, Inc.
ZigBee is a trademark of ZigBee Alliance.

1.1.4 Printed-Circuit Board Assemblies

The TLC5944EVM-358 EVM kit contains three printed-circuit boards: HPA358 (Driver board), HPA357 (LED board), and TMDSCNCD2808 (DSP board).

Driver Board: The Driver board contains the TLC5944 ICs and their required external components. This board contains several jumpers and connectors that enable you to customize the board for specific operating conditions. This board interfaces directly to the host computer via a USB connector. The EVM GUI software communicates with the Driver board through a TUSB3410. The TUSB3410 communicates with the DSP board with an RS-232 protocol. The Driver board contains resistors R16-R27 that set a binary code to tell the DSP what EVM is connected. It contains all power supply circuitry as well as circuitry containing Q1 and Q2 to enable and disable the ghosting features of the IC. The Driver board is designed to directly drive the LED board; however, the customer may also remove the LED board to drive a custom LED board.

LED Board: The LED board contains two rows of LEDs. Row A consists of 16 LEDs, each with three individual LEDs in the same package: a red, a green, and a blue LED. Row B consists of a 16 LEDs, each with a single red LED. It also contains the circuitry required to multiplex between Row A and Row B. A digital signal, ROW_CTRL_0, from the Driver board connects power to Row A when high and connects power to Row B when low. The orderable Texas Instruments part number for this PCB is LEDEV-357.

DSP Board: The DSP board contains a TMS320F2808 ('F2808) microcontroller that programs and controls the three TLC5944 ICs on the Driver board. The 'F2808 DSP decodes the information it receives from the LED Driver board and converts it into a form required by the TLC5944 ICs. The DSP board's orderable part number is TMDSCNCD2808. [Figure 1](#) shows how these boards are connected.

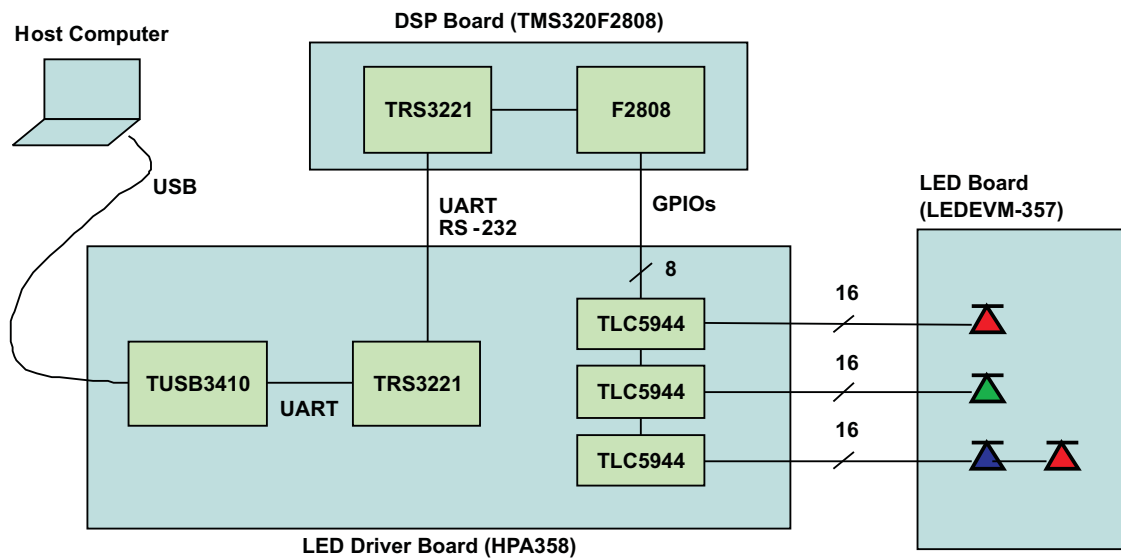


Figure 1. Board Connections

1.2 Related Documentation From Texas Instruments

1. TLC5944, 16-Channel, 12-Bit PWM LED Driver With 6-Bit Dot Correction and Pre-Charge FET data sheet ([SBVS112](#))
2. TLC5944 software ([SLVC186](#))
3. TMDSCNCD2808 DSP controlCARD™ documents ([SPRR101](#))

2 Setup

This section describes the jumpers and connectors on the EVM as well as how to properly connect, set up, and use the TLC5944EVM-358.

2.1 Input/Output Connector Descriptions

2.1.1 J1 – USB Input Connector

This mini-USB connector connects the EVM directly to the host PC's USB port.

2.1.2 J2 – ZigBee™ Input Connector

This connector mates to the HPA358 LED board. The customer also can connect a custom board to this connector with a 30-pin ribbon cable. To minimize stray inductance and ringing on the output traces, make connections to this connector as short as possible. This connector allows the user to connect ZigBee devices such as the eZ430-RF2500. The user can write customized code to control the TLC5944EVM with a wireless ZigBee connection. J2 is not populated or used with the supplied EVM software.

2.1.3 J3 – RS-232 Input Connector

This connector allows the user to connect an RS-232 device. The user can write customized code to control the TLC5944EVM or to modify the DSP board's firmware. J3 is not populated or used with the supplied EVM software.

2.1.4 J4 – DSP Board Connector

The DSP board plugs into the J4 connector on the Driver board.

2.1.5 J5 – JTAG Input Connector

This connector can be used for JTAG communications to help debug user-generated software. J5 is not populated or used with the supplied EVM software.

2.1.6 J6 – VIN

This is the positive input supply to the EVM. The input voltage must be between 5 V and 15 V for normal operation with no multiplexing. When Row A and Row B are multiplexed by checking the Ghosting Demo button in the software, the maximum operating voltage is 10 V. The 10-V maximum voltage is limited by switching losses in the FETs on the LED board. The EVM can be operated with 15 V when multiplexing, if forced air cooling is used on the LED board. To minimize power dissipation, the input voltage must be as low as possible. The leads to the input supply must be twisted and kept as short as possible to minimize EMI transmission.

2.1.7 J7 – GND Connector

This connector is the return for the input supply to the EVM. The leads to the input supply must be twisted and kept as short as possible to minimize EMI transmission.

2.1.8 J8 – Input Power Connector

This is a right-angle miniature power jack with a 3.5-mm diameter connection. The user can use this connector to supply input power to the EVM from an ac-to-dc plug-in adapter. The inner pin on the connector is connected directly to J6 (Vin). The outer pin on the connector is connected directly to J8 (GND). When using an ac-to-dc plug-in adapter, ensure that the plug-in adapter's output voltage is stable and does not drop below 5 V when loaded.

2.1.9 J9 – Communications Connector

This connector contains shorting shunts that connect the 'F2808 DSP to the TLC5944 LED drivers. The shunts are preconfigured to properly connect the DSP's GPIO control signals to the LED driver ICs. The GND pins on this connector do not need shorting shunts because these pins are connected to the ground plane of the PCB. The user can remove all shorting shunts to disconnect the 'F2808 from the TLC5944 ICs. This allows the user to connect control signals from a separate microprocessor to this connector to program the LED drivers. The XERR signal does not need a shorting jumper because the user graphical interface (GUI) software does not use this signal.

CAUTION

Do not drive the outputs of the TMS320F2808 on the DSP board with external control signals.

2.1.10 J10 – LED Connector

This connector mates to the HPA358 LED board. The user also can connect a custom board to this connector with a standard 30-pin ribbon cable with 0.1-inch pin-to-pin spacing. In order to minimize stray inductance and ringing on the output traces, connections to this connector must be as short as possible.

2.1.11 J11 – LED Connector

This connector mates to the HPA358 LED board. The user also can connect a custom board to this connector with a standard 30-pin ribbon cable with 0.1-inch pin-to-pin spacing. In order to minimize stray inductance and ringing on the output traces, connections to this connector must be as short as possible.

2.1.12 JP1 – Default 'F2808 Boot Location

When a short is connected between pins 1-2, the 'F2808 boots up from the USB port connector, J1. When a short is connected between pins 2-3, the 'F2808 boots up from its internal flash EEPROM. The default boot location is the 'F2808 internal EEPROM. Firmware updates to the EEPROM require changes to the JP1 settings. The GUI software provides detailed instructions on how to update the firmware. If the user configures the EVM to communicate through the RS-232 or Zigbee connector, short JP1 pins 1 and 2 together so that the DSP boots from the RS-232 or Zigbee connector.

2.1.13 JP2 – Red LED

This jumper must be shorted to connect the red LED driver's OUT15 pin to the red LED. This jumper can be opened to measure the current flowing into the OUT15 pin from the red LED.

2.1.14 JP3 – Green LED

This jumper must be shorted to connect the green LED driver's OUT15 pin to the green LED. This jumper can be opened to measure the current flowing into the OUT15 pin from the green LED.

2.1.15 JP4 – Blue LED

This jumper must be shorted to connect the blue LED driver's OUT15 pin to the blue LED. This jumper can be opened to measure the current flowing into the OUT15 pin from the blue LED.

2.1.16 JP5 – SCL

This jumper is used to program the EEPROM, U1, at assembly. This jumper must be shorted to connect the TUSB3410 to the EEPROM for normal operation.

2.1.17 JP6 – SDA

This jumper is used to program the EEPROM, U1, at assembly. This jumper must be shorted to connect the TUSB3410 to the EEPROM for normal operation.

2.1.18 S1 – Power Switch

This switch connects and disconnects input power from the EVM.

2.2 Software Setup

If installing from a CD, insert the CD and run Setup.exe. Follow all the prompts to allow the software to be installed.

If installing from the TI Web site, go to the URL www.ti.com

Note: This installation page is best viewed with Microsoft Internet Explorer™ browser. It may not work correctly with other browsers.

Click on the install button; your PC gives you a security warning and asks if you want to install this application. Select Install to proceed.

With both types of installation, the software attempts to install the Microsoft Dot Net Framework 2.0 (if it is not already installed). This framework is required for the software to run.

After installation, the software automatically runs.

During future use of the software, it may prompt you to install a new version if it becomes available on the web.

Note: VeriSign™ code signing is used to prevent any malicious code from changing this application. If at any time in the future the binaries are modified, the code no longer attempts to run.

2.3 Hardware Setup

Ensure that S1 is in the OFF position.

Ensure that the shorting shunt is installed on JP1. The default for normal EVM operation is to short pins 2 and 3 together.

Ensure that the shorting shunts are installed on JP2, JP3, JP4, JP5, and JP6.

Connect the LED board (HPA358) to the LED Driver board (HPA274).

Connect the DSP board (TMDSCNCD2808) to the LED Driver board (HPA274). Ensure the DSP board is fully seated in J4 with the tabs positioned to lock the DSP board in place.

Connect the LED Driver board to the host computer using the supplied USB cable.

Using either the J6 and J7 input power connectors or the J8 power jack connector, connect an input voltage supply to the TLC5944EVM board. The TLC5944 requires an input voltage between 5 V and 10 V. The input supply must be capable of supplying at least 1.5 A. Note that some ac-to-dc plug-in adapters do not provide clean power. Ensure that the input voltage is well regulated to avoid intermittent communication problems.

CAUTION

Hot plugging the input supply with long leads can generate transients on the input supply bus that exceed the maximum ratings of the EVM. The input supply must be connected before it is turned on.

- Turn on the input supply voltage.
- Move S1 from OFF to ON.
- The 16 LEDs now are displaying a default pattern.

3 Operation

This section provides instructions on how to turn on the TLC5944EVM and operate the software.

The user now can run the host computer software and change the LED programming with the easy-to-use graphical interface.

3.1 Running the Software

Click on the TLC594x EVM GUI icon on the host computer to start the software. If no icon appears on the host computer, then use the start button in the lower left corner of the screen to browse the program folders to find the software. The default directory for software installation is Program Files\Texas Instruments\TLC594x EVM GUI Application. The executable file name is TLC594x.exe. Once started, the software checks the firmware in the DSP board to ensure it is compatible with the software. If the firmware is not compatible, the software gives the user instructions on how to reprogram it. Once the software is started and communication is established between the GUI and the EVM, the user can use the graphical interface to program the LEDs. If the EVM is properly connected, the software screen looks like [Figure 2](#) when first opened.

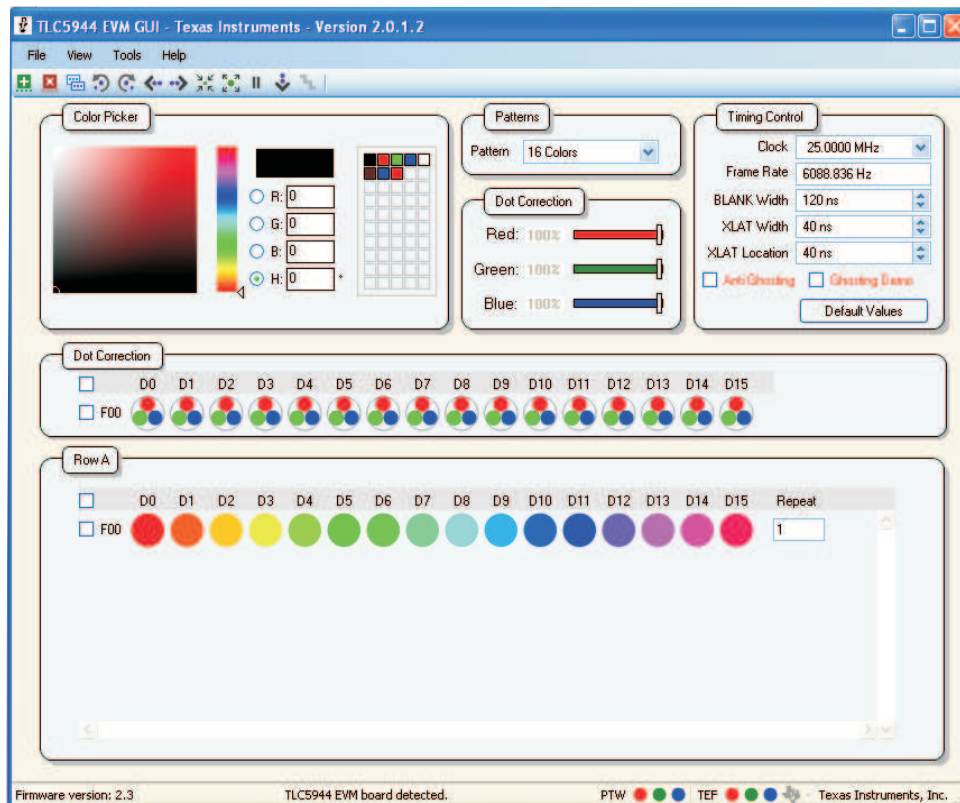


Figure 2. TLC5944EVM Software Start-Up Screen

3.2 Software Features

3.2.1 Color Picker

This window allows the user to choose the red, green, and blue PWM value for each LED. The software provides three options for choosing an LED's color. The user can manually enter the PWM values into the three text boxes, use the mouse to pick colors from the color bars, or use the mouse to click on a color from the custom color pallet. The color chosen in the Color Picker window is immediately displayed in the LEDs that are highlighted in the LED Frames window. The user can add custom colors to the pallet by dragging the current color to the custom color pallet. Custom colors can be deleted by right-clicking on the color to be removed. The TLC5944 is capable of displaying the full 2^{12} , or 4096 brightness levels per LED.

3.2.2 Patterns

This window provides the user with several preprogrammed LED frame patterns. Choosing a pattern immediately programs the LED Frames window with the pattern and then displays the pattern with the LEDs.

3.2.3 Dot Correction

These two windows allow the user to individually control the EVM's red, green, and blue dot correction values. Each LED's Dot Correction value can be individually programmed. Dot Correction data is only written to the EVM when one of the three values change. To change an LED's dot correction value, select individual LEDs by clicking on each LED or select all LEDs by checking the box to the left of the LEDs. Then adjust the Dot Correction value. The programmed Dot Correction value is used for all frames. Dot Correction values can not be changed from frame to frame.

3.2.4 Timing Control

The options in this window allow the user to modify the timing parameters of the signals written to the TLC5944 ICs. Note that all times and frequencies are approximate.

Clock: This drop-down menu allows the user to select the EVM's serial clock (SCLK) and grayscale (GSCLK) frequencies. The available clock frequencies are integral divisions of the 'F2808 clock frequency and cannot be modified.

Frame Rate: This shows the refresh rate for a single frame update. The Frame Rate is approximately $1/\text{period}$, where period is the time to display all 2^{12} grayscale pulses at the chosen clock frequency plus the time the BLANK signal is high.

BLANK Width: This adjusts the width of the BLANK pulse.

XLAT Width: This adjusts the width of the XLAT pulse.

XLAT Location: This adjusts the rising edge of the XLAT pulse location. It is relative to the rising edge of the BLANK signal. A negative XLAT Location is shown when the XLAT signal rises before the BLANK signal.

Default Values: This box resets all Timing Controls to their default values.

3.2.5 Anti-Ghosting

When not checked, the EVM does not supply power to the TLC5944 VUP pins. This allows the LEDs to show ghosting in the ghosting demo. When checked, the EVM applies power to the TLC5944 VUP pins which enables the Pre-Charge FETs to eliminate the visible ghosting.

3.2.6 Ghosting Demo

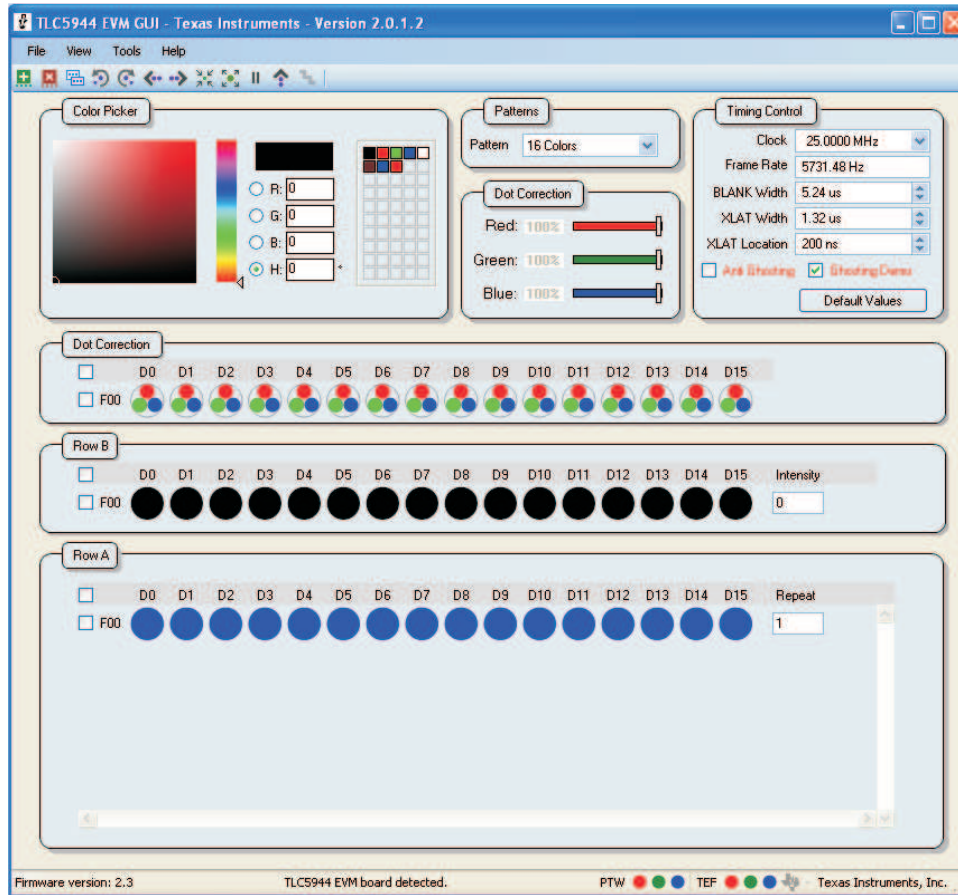


Figure 3. TLC5944EVM Software with Ghosting Demo Enabled.

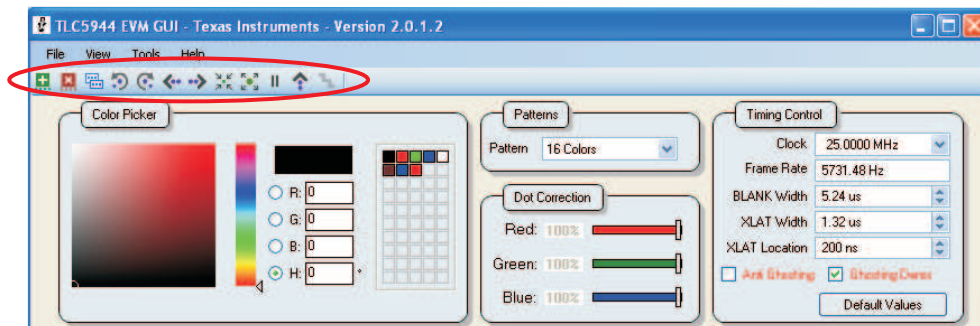
When not checked, the EVM GUI is configured as shown in [Figure 3](#). The GUI commands the EVM to only supply power to the Row A LEDs. When checked, the GUI reconfigures itself as shown in [Figure 3](#). The GUI now commands the EVM to switch power back and forth between the Row A and Row LEDs. The LED Board and Timing Control Settings are optimized to show visible ghosting. When the Ghosting Demo is enabled, the red LEDs in Row B are visually illuminated, even when programmed to be off. The user can now program the Row A and Row B LEDs separately. Note that Row B LEDs are red and can only be programmed with a red intensity value between 0 and 4095 with the Intensity field in the Row B window.

WARNING

When using the Ghosting Demo, the input voltage must be less than 10 V.

3.2.7 LED Frames

The LED tool bar provides many easy-to-use functions to facilitate the EVM's evaluation. Each button has a pop-up description, which makes each function self-explanatory.



3.2.8 File – Save and Load

This tab allows the user to save and load custom frames. The file also saves all user-selectable settings such as operating frequency and Dot Correction settings.

3.2.9 View – Editing Radix

Changes the input format for the PWM Grayscale values in the Color Picker and Dot Correction Values between Hex, Percentage, and Absolute.

3.2.10 View – LED Display Mode

When Solid display mode is chosen, the pixel in the LED Frames window shows the LED pixels and their approximate color on the EVM. This color is generated by the mixing of the three individual LED colors. When RGB display mode is chosen, the pixel shows the relative intensity of each individual LED that makes up each pixel.

3.2.11 Tools – Update DSP Firmware

Clicking on this function provides step-by-step directions on how to update the EVM's DSP firmware.

3.2.12 Information Bar – EVM Status

The information bar displays whether or not the GUI detects the EVM hardware.

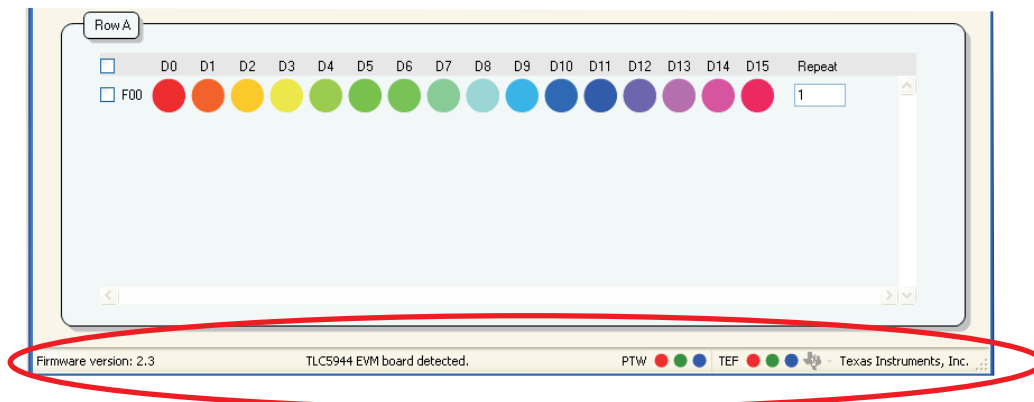


Figure 4. Information Bar

3.2.13 Information Bar – Firmware Version

This shows the user the DSP's firmware version.

3.2.14 Information Bar – Thermal Error Flag

The right side of the information bar displays three LED colors representing the thermal error flag for each TLC5944 on the EVM. In normal operation, the error flag is a solid color. When an IC detects an overtemperature condition, the colored circle turns into a burning IC. The EVM firmware latches the TLC5944 overtemperature signals to ensure that the GUI is able to read and display the error signals. The GUI can show an error condition for 2 seconds longer than the condition actually exists on the hardware.

3.2.15 Information Bar – Pre-Thermal Warning

The right side of the information bar displays three LED colors representing the pre thermal warning flag, PTW, for each TLC5944 on the EVM. In normal operation, the error flag is a solid color. When an IC detects a junction temperature above 120 deg, the colored circle turns into a burning IC. The EVM firmware latches the TLC5944 PTW signals to ensure that the GUI is able to read and display the error signals. The GUI can show an error condition for 2 seconds longer than the condition actually exists on the hardware. Note that the PTW does not affect device operation.

3.3 Hardware Features

3.3.1 EVM Binary Identification Code

Resistors R16-R27 set a binary code that is read by the DSP at start-up. The DSP communicates this code to the GUI so that it knows what version of the EVM is connected and can load the proper software version.

3.3.2 RS-232 Communication Frequency

Resistors R28-R30 set a binary code that sets the default RS-232 communication frequency. [Table 1](#) shows the available settings. The default frequency is 115.2 kbps. The user can change this setting for custom software and communication protocol development.

Table 1. Available Settings

Default Frequency	GPIO 10	GPIO 9
9.6 kbps	0	0
57.6 kbps	0	1
115.2 kbps	1	0
Not used	1	1

3.3.3 Impedance Matching Termination Network

Each control line contains an RC impedance matching termination network. These are shown in the lower right corner on page 4 of the schematic. These networks are not installed and are not needed when using the DSP board to drive the LED drivers. If the user drives the LED drivers from an external source, these components may need to be installed to provide proper impedance matching of the PCB traces and the external drive circuitry. Excessive ringing caused by impedance mismatch can be interpreted as low-to-high logic level changes, causing erratic EVM behavior.

4 Schematics, Board Layouts, and Bill of Materials

4.1 Schematics

Figure 5 through Figure 11 provides the schematics for the TLC5944EVM-358 and the LEDEV-249.

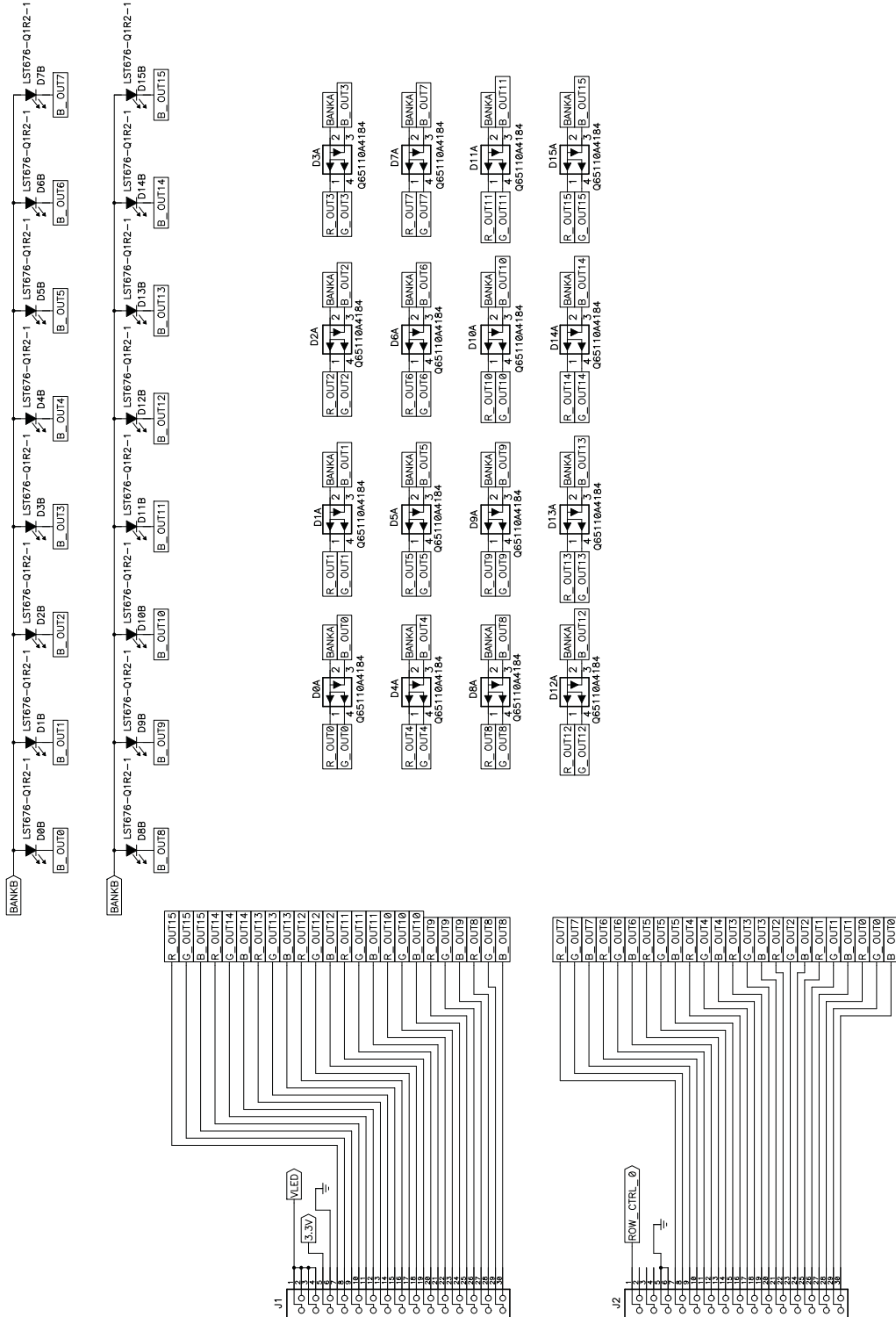


Figure 5. HPA357A - Schematic 1

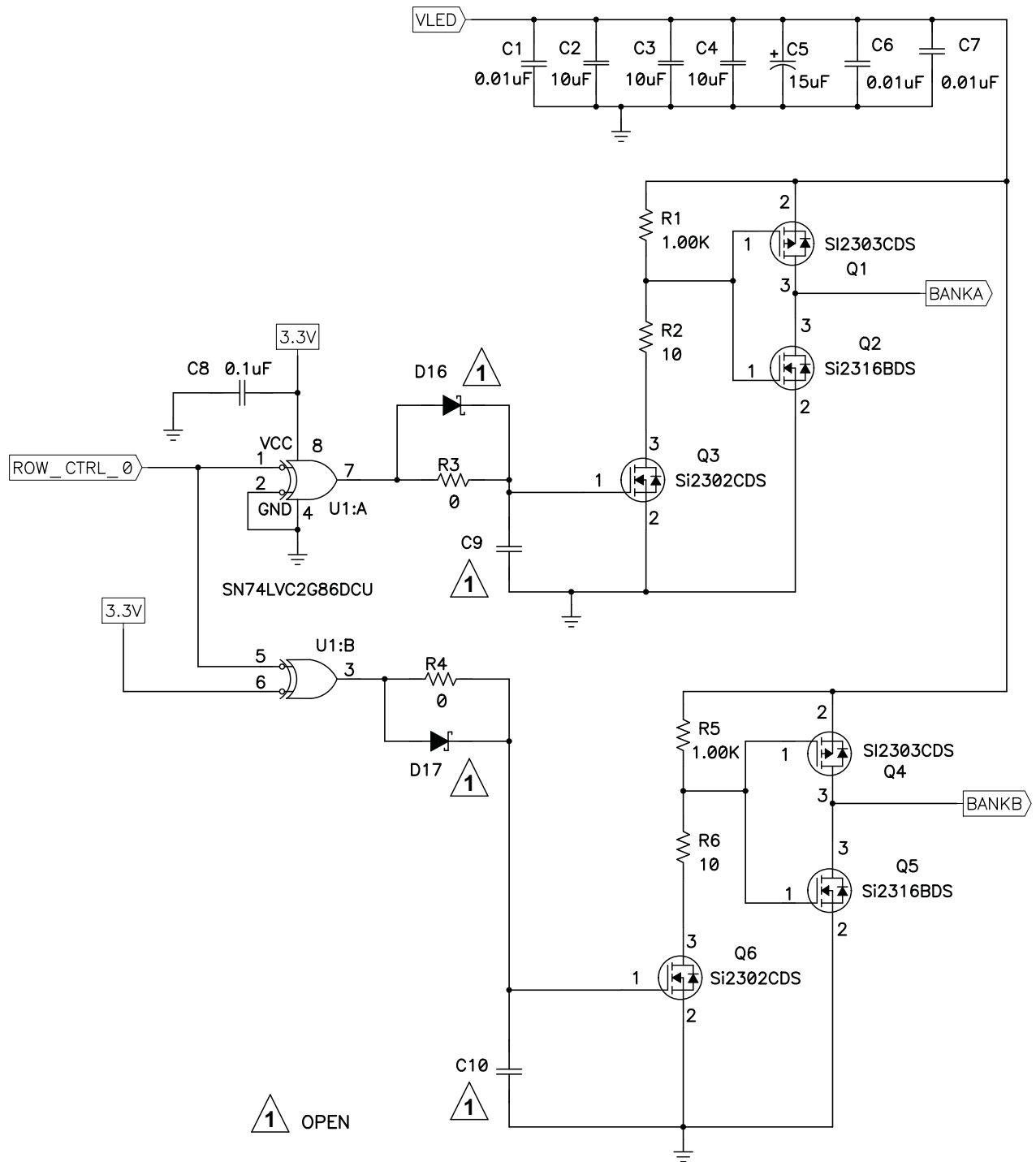


Figure 6. HPA357A - Schematic 2

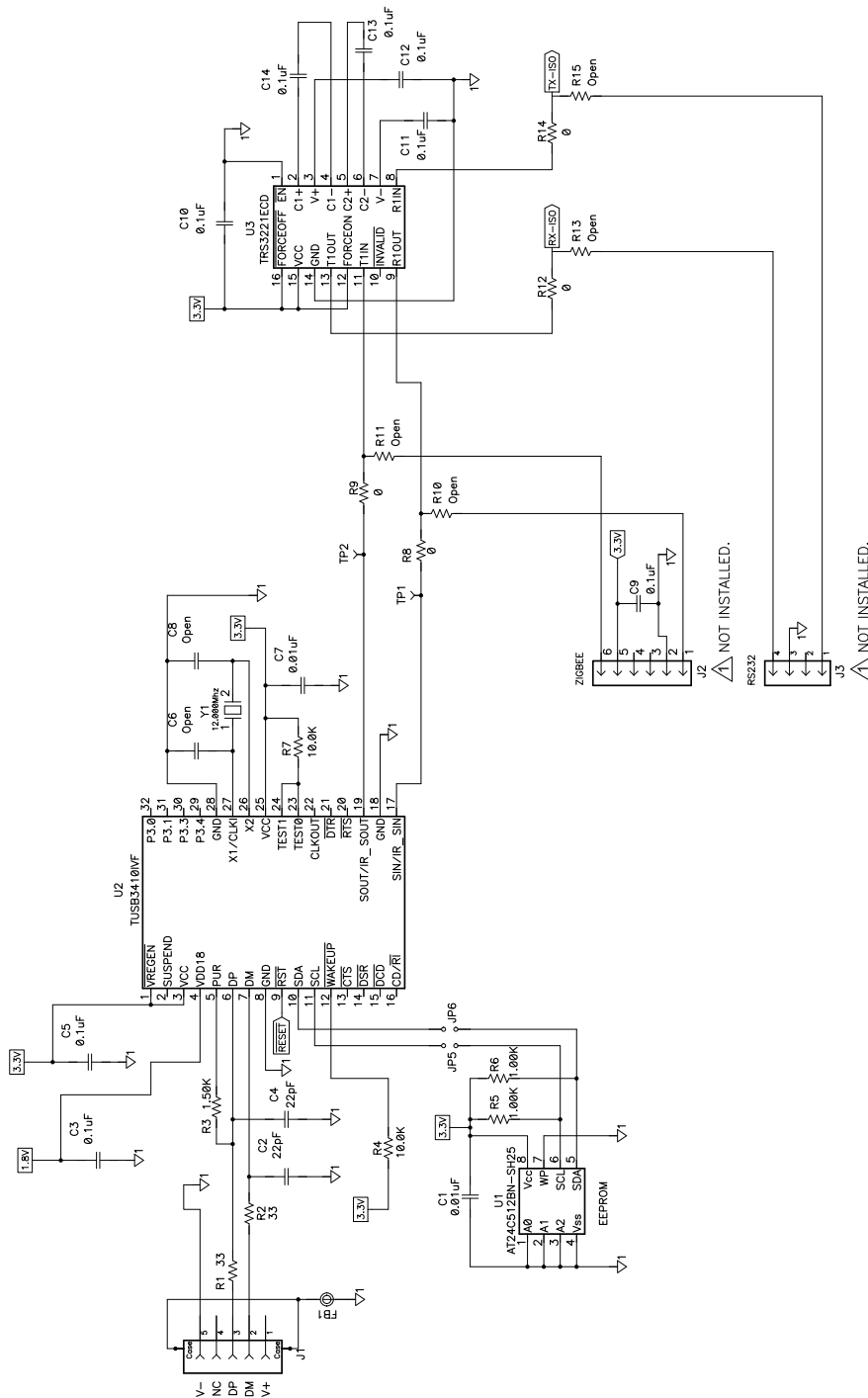


Figure 7. HPA358A Schematic 1

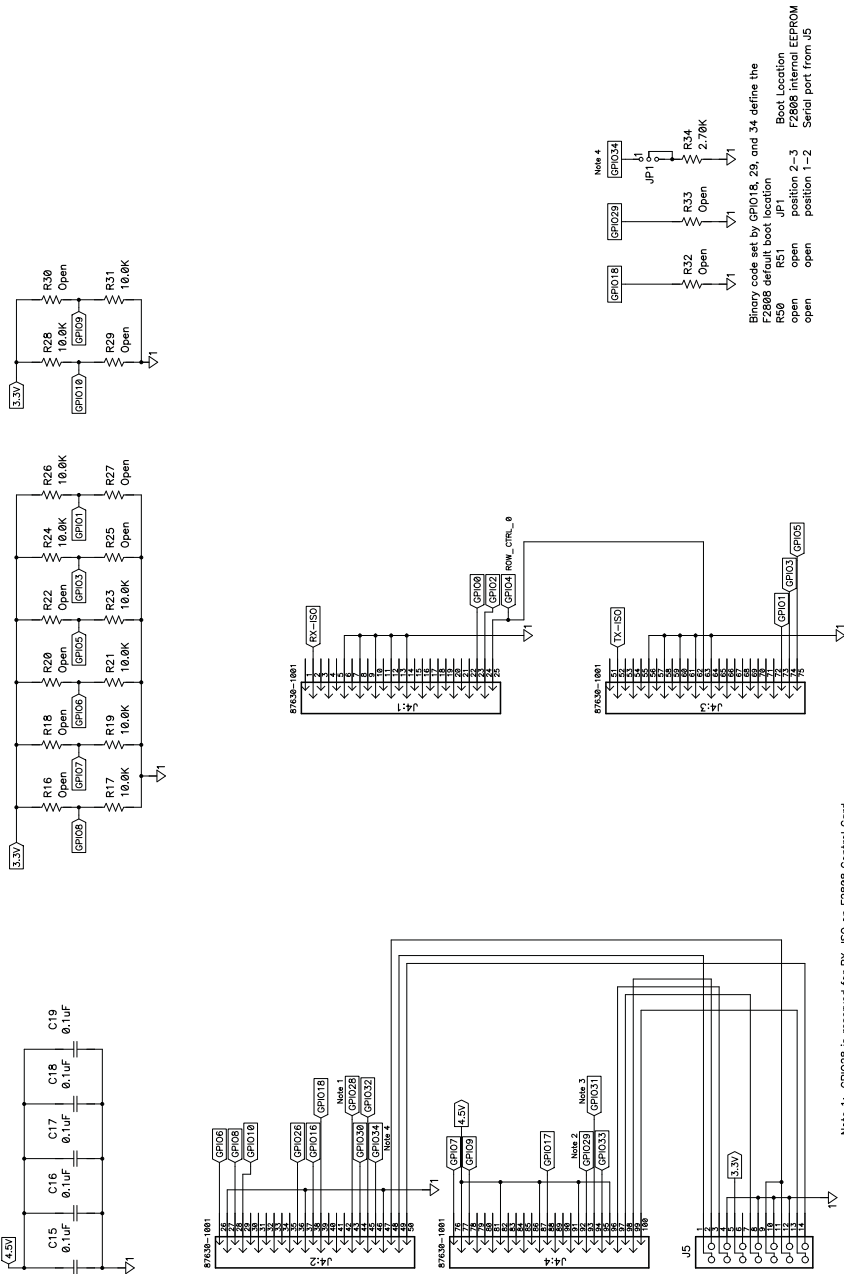


Figure 8. HPA358A Schematic 2

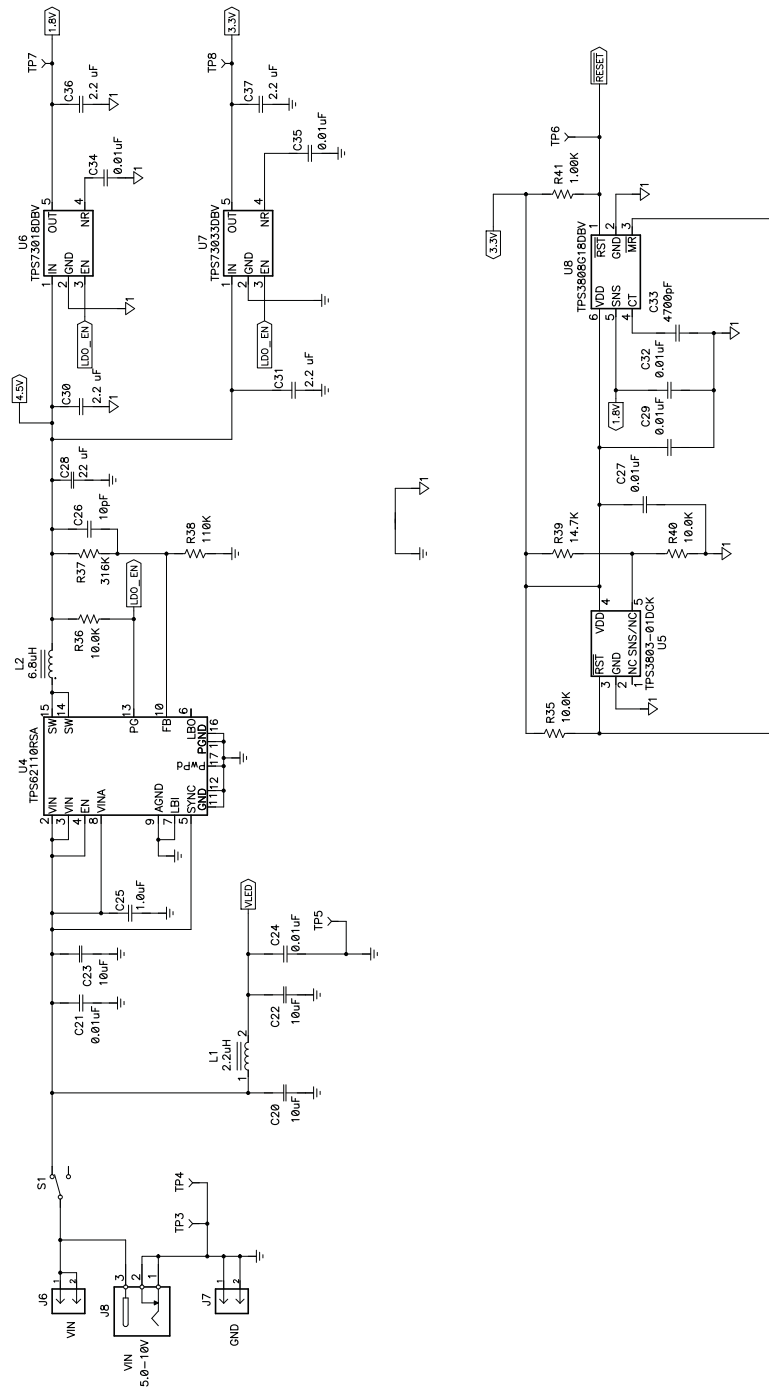


Figure 9. HPA358A Schematic 3

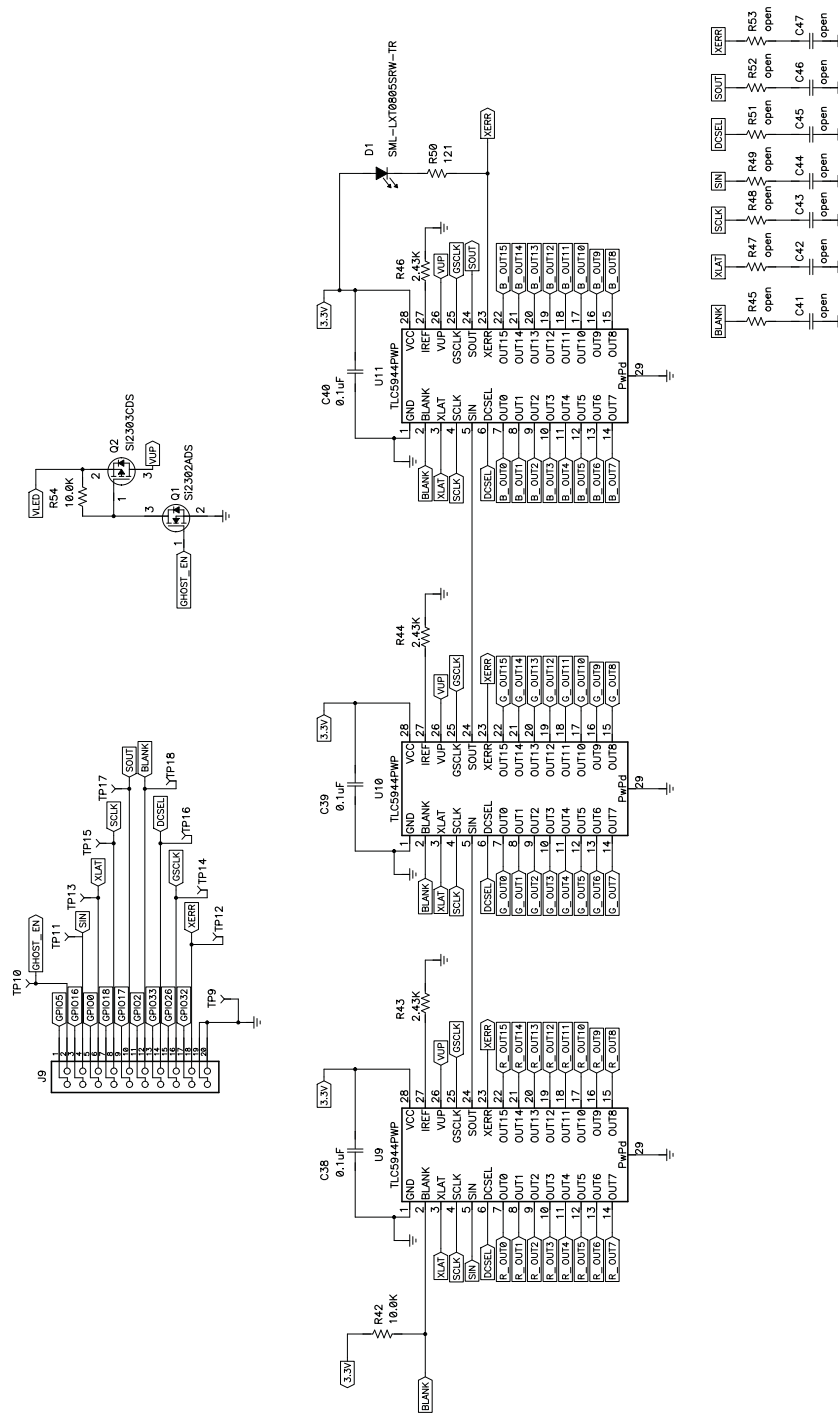


Figure 10. HPA358A Schematic 4

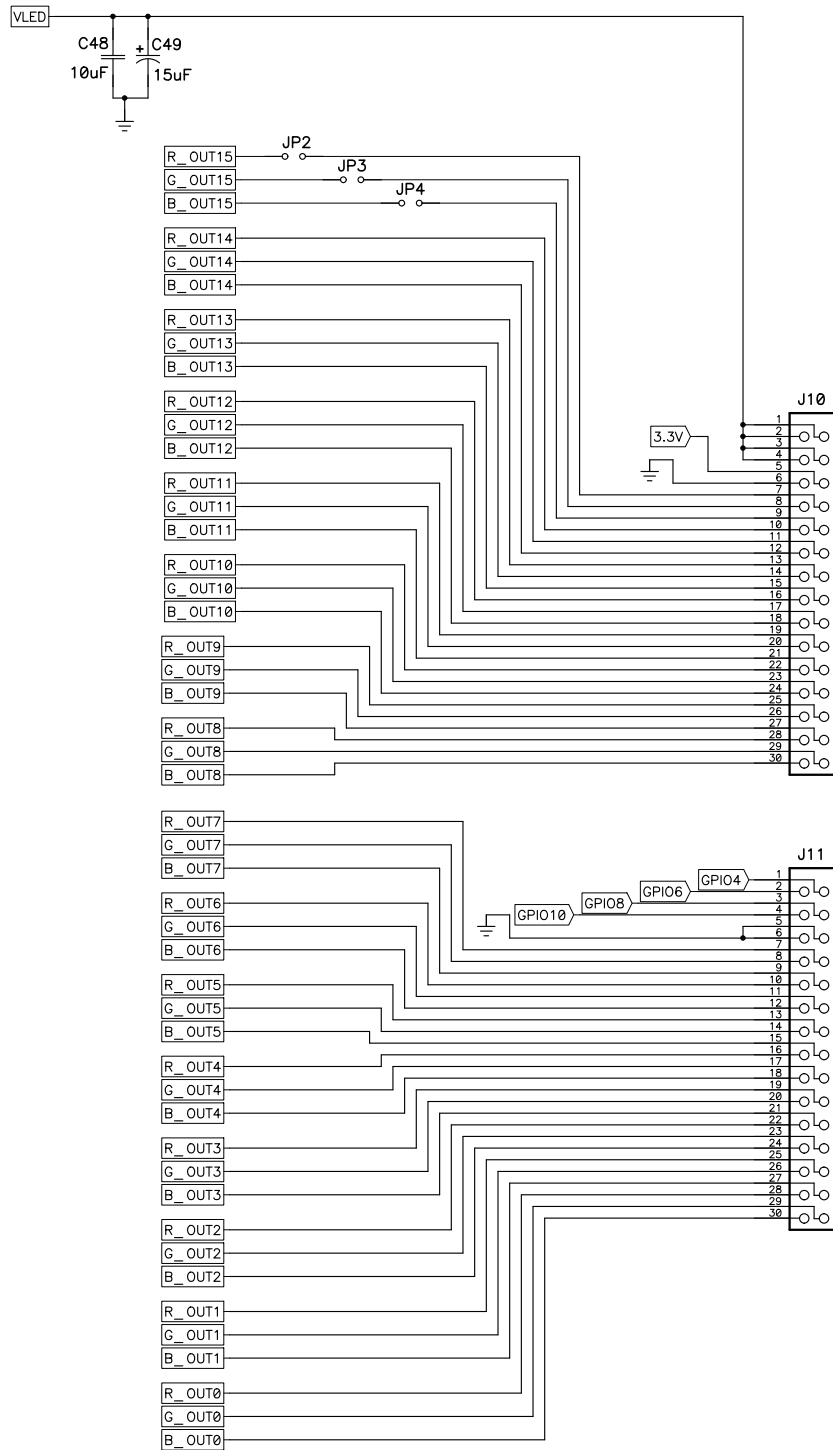


Figure 11. HPA358A Schematic 5

4.2 Board Layouts

This section provides the TLC5944EVM-358 and LEDEV-357 board layouts and illustrations.

Figure 12 through Figure 16 show the board layout for the LED driver board, HPA357.

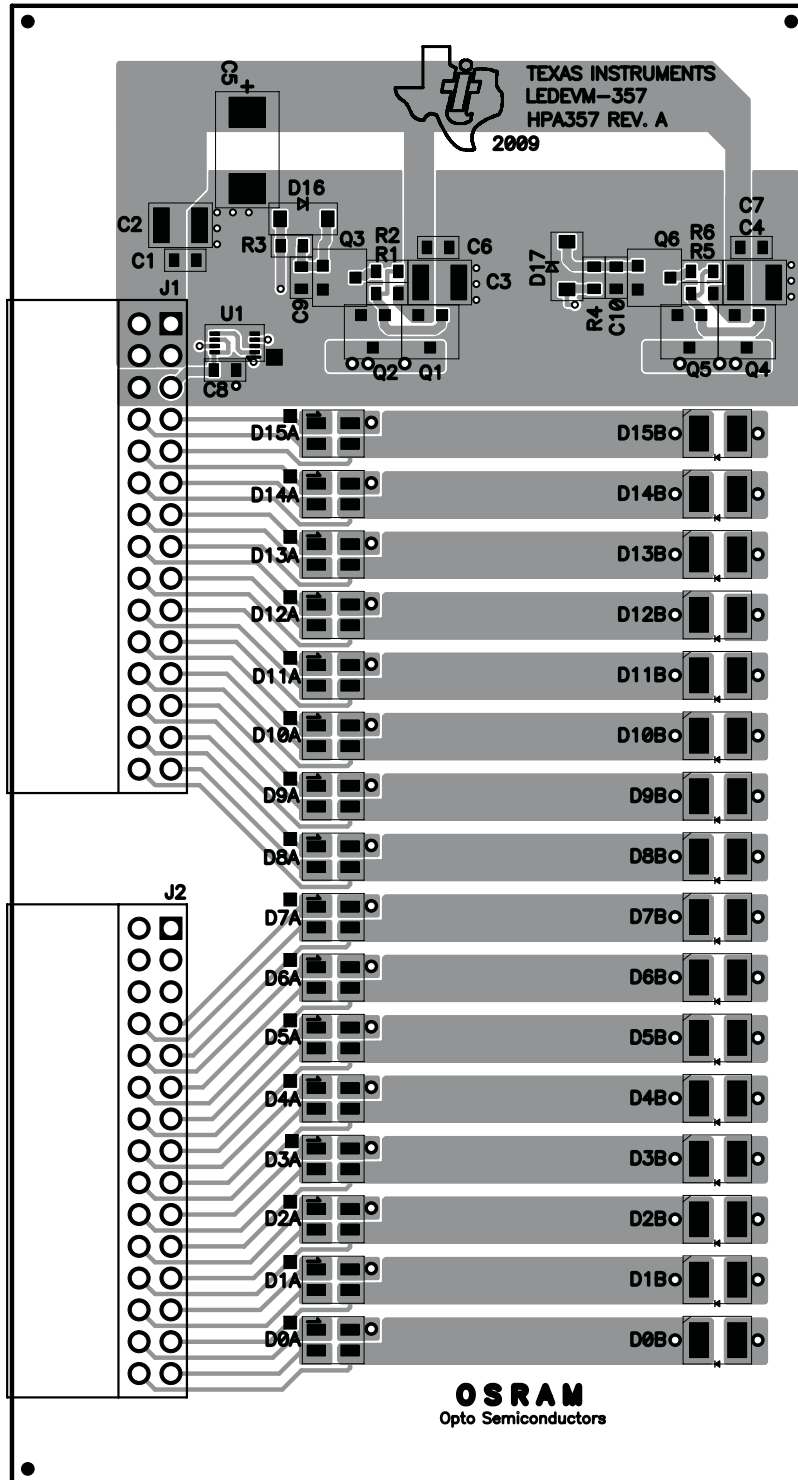


Figure 12. HPA357A Assembly Layer Routing

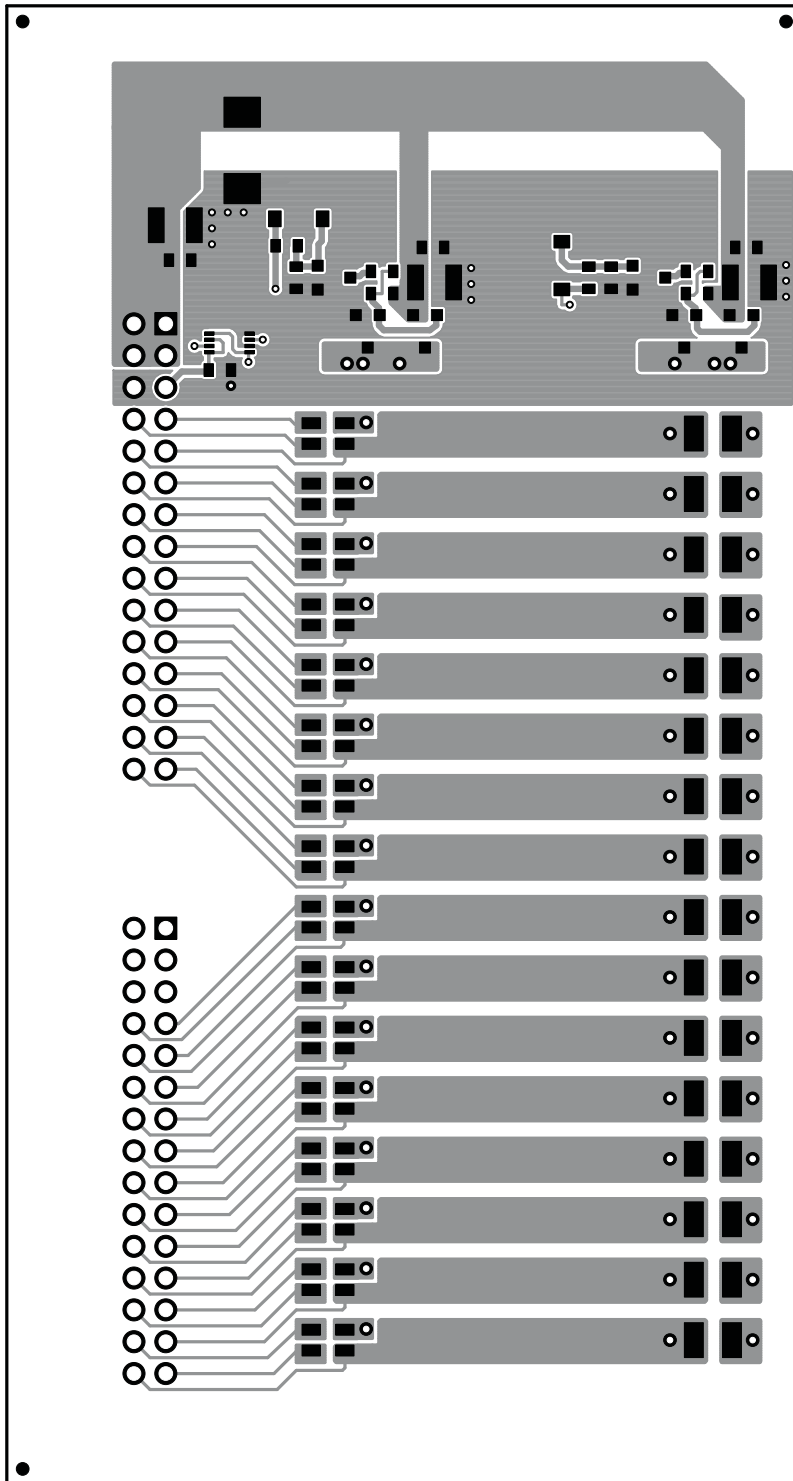


Figure 13. HPA357A Top Layer Routing

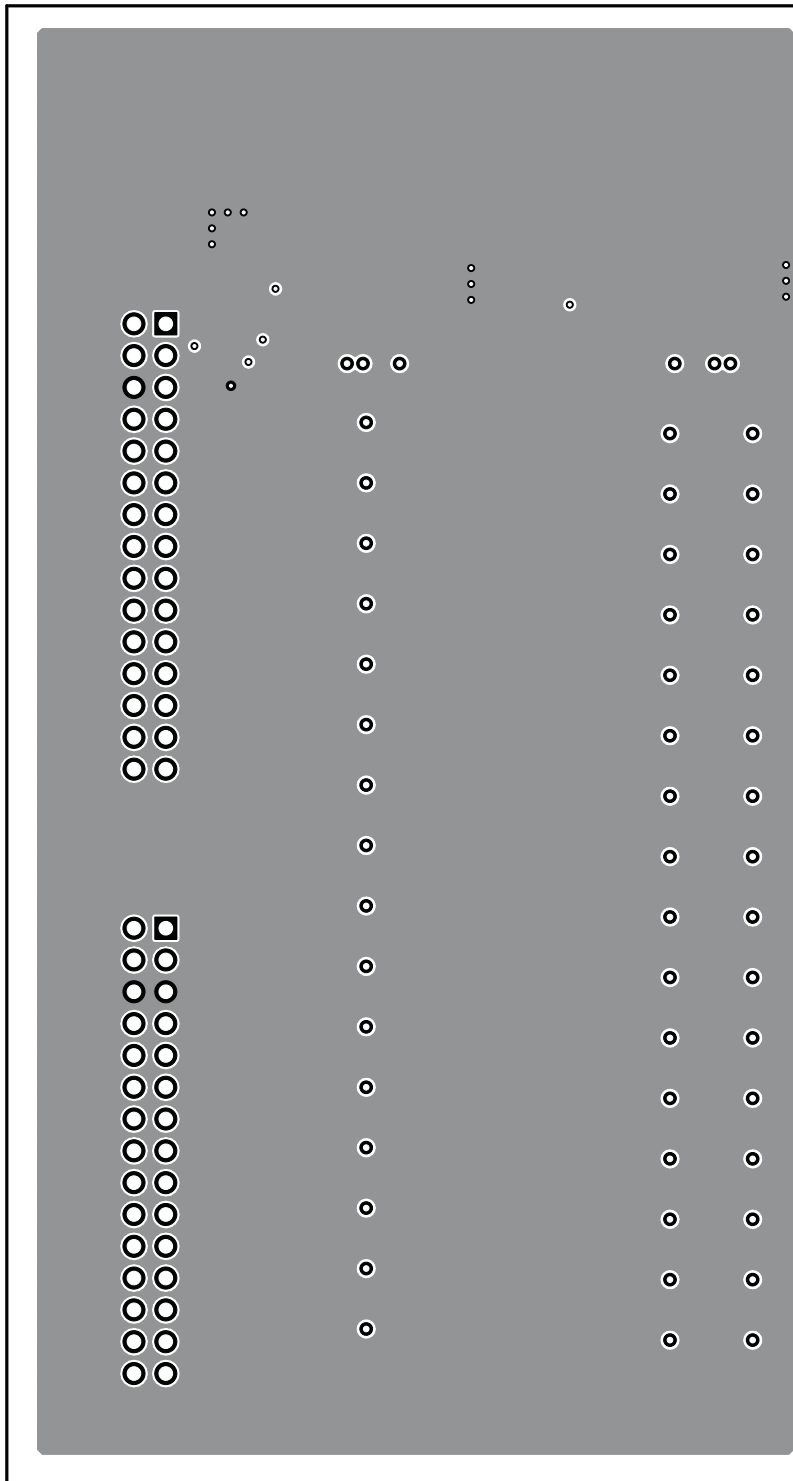


Figure 14. HPA357A Layer 2 Routing

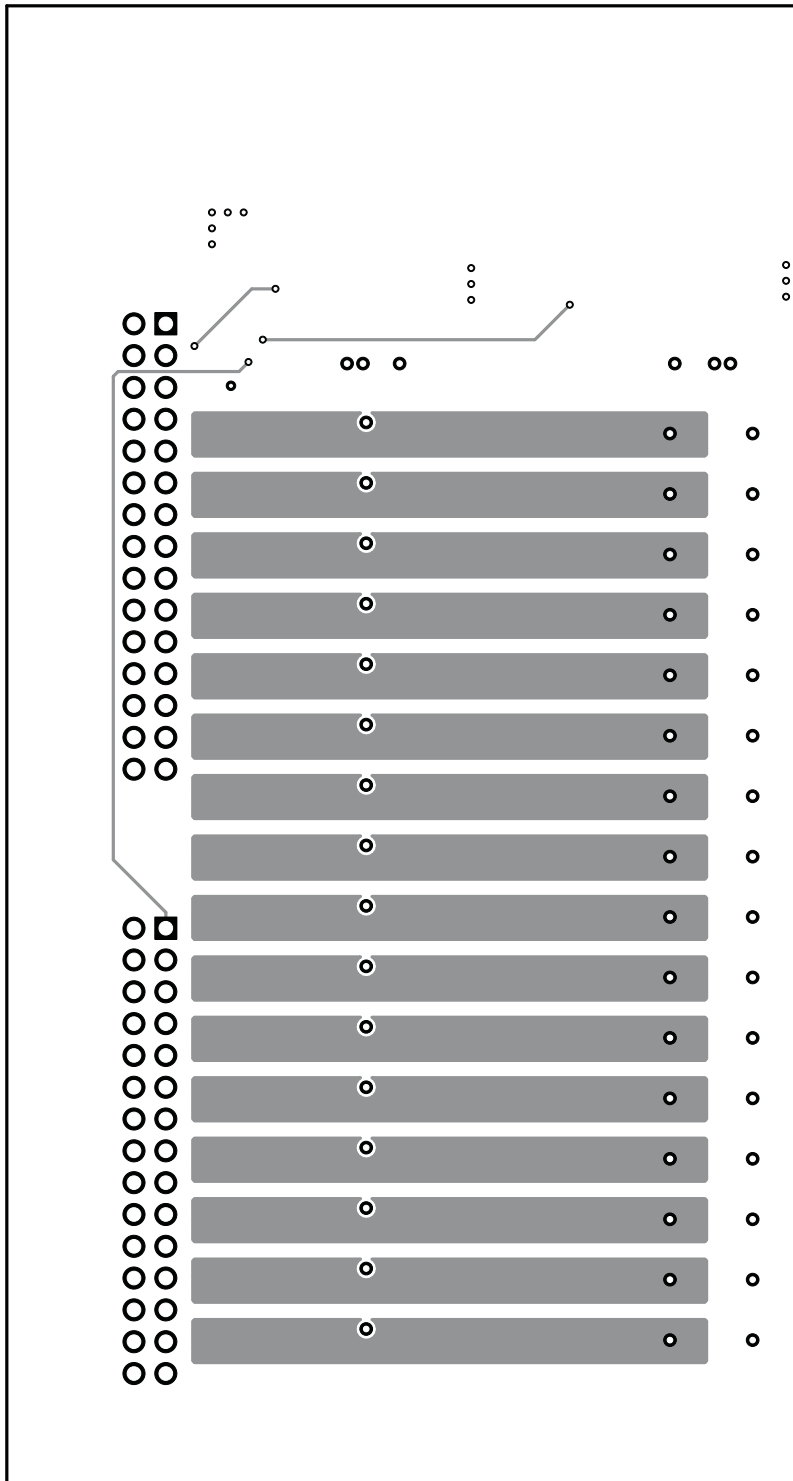


Figure 15. HPA357A Layer 3 Routing

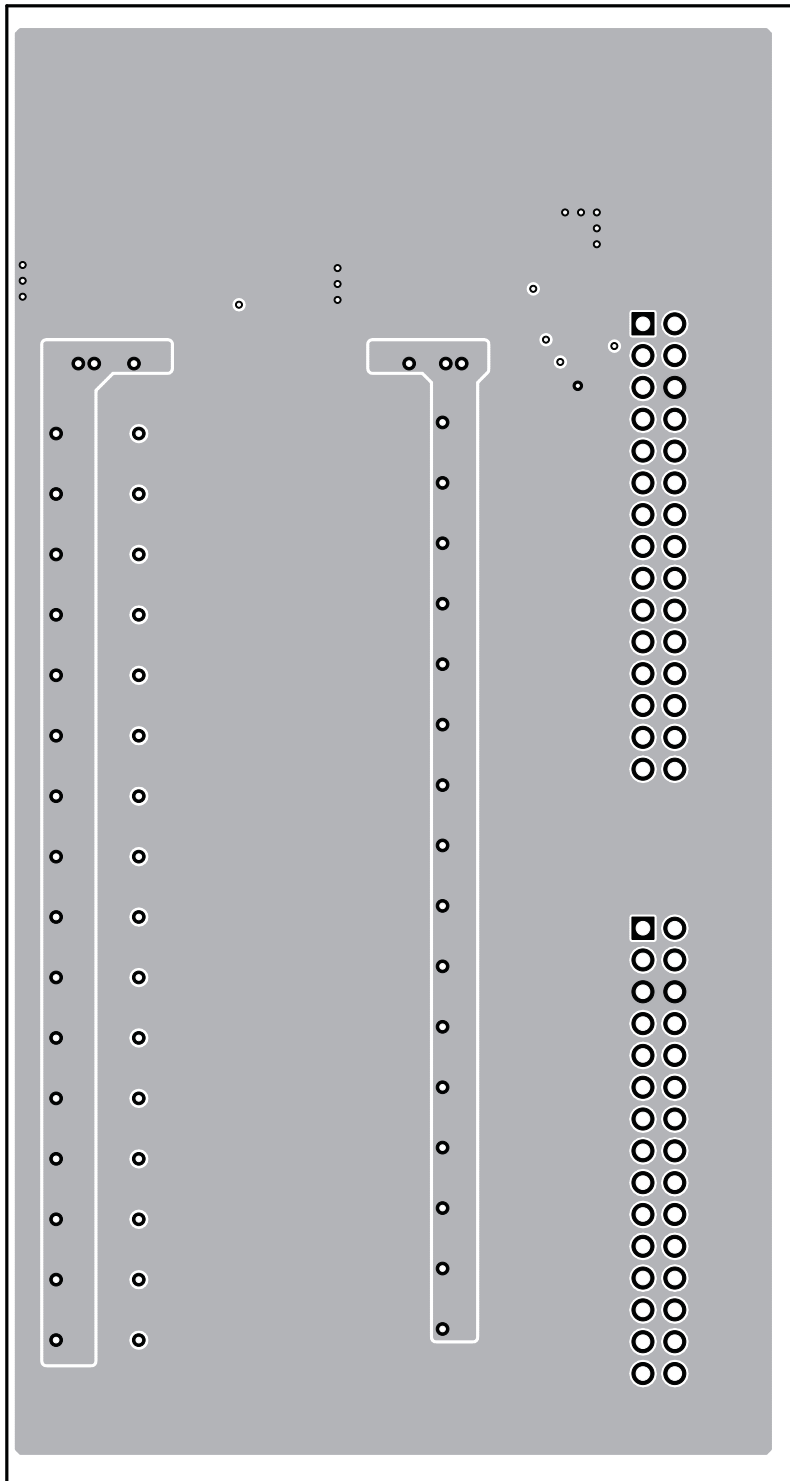


Figure 16. HPA357A Bottom Layer Routing

Figure 17 through Figure 19 show the board layout for the LED board, HPA358.

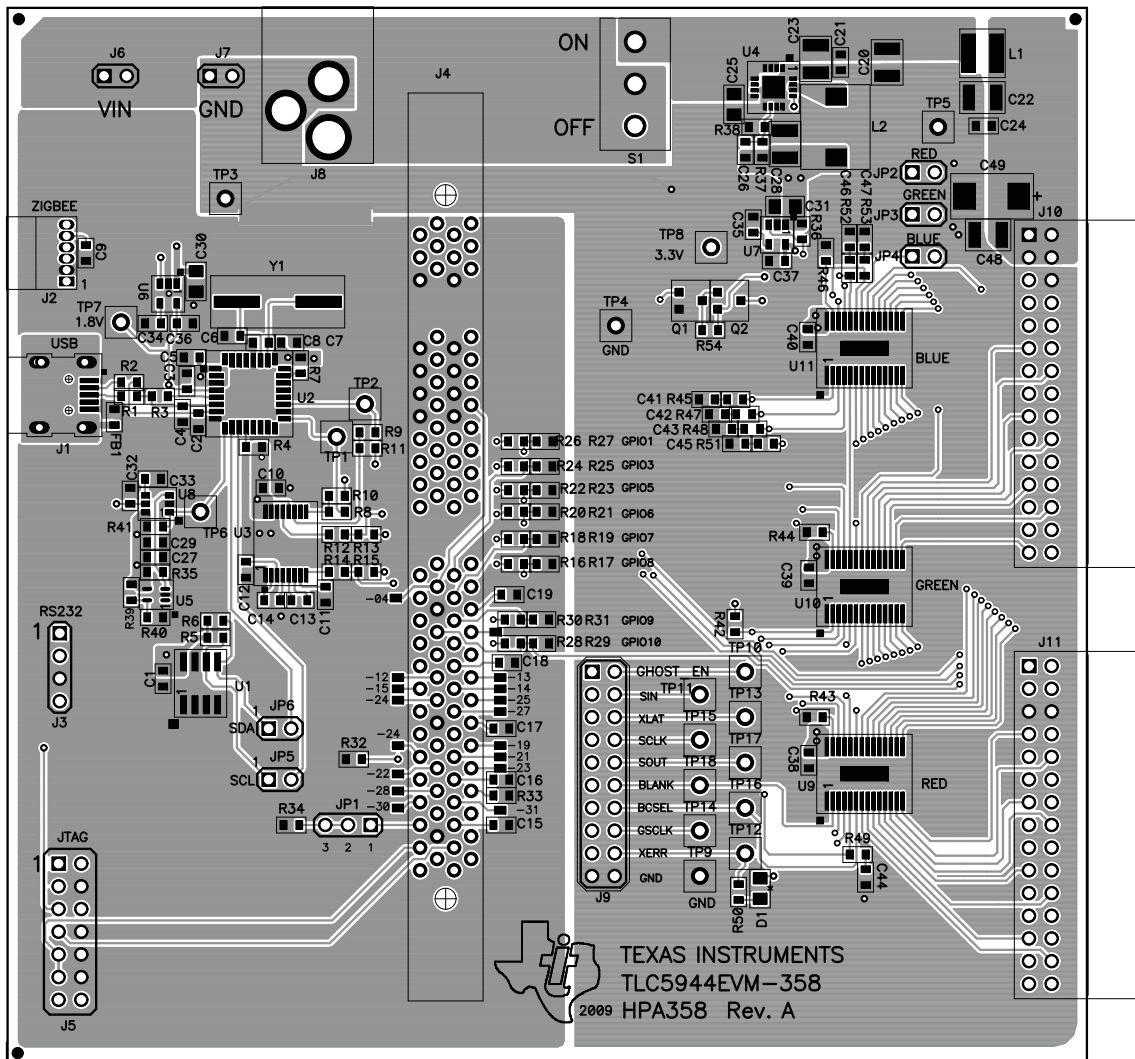


Figure 17. HPA358A Assembly Layer

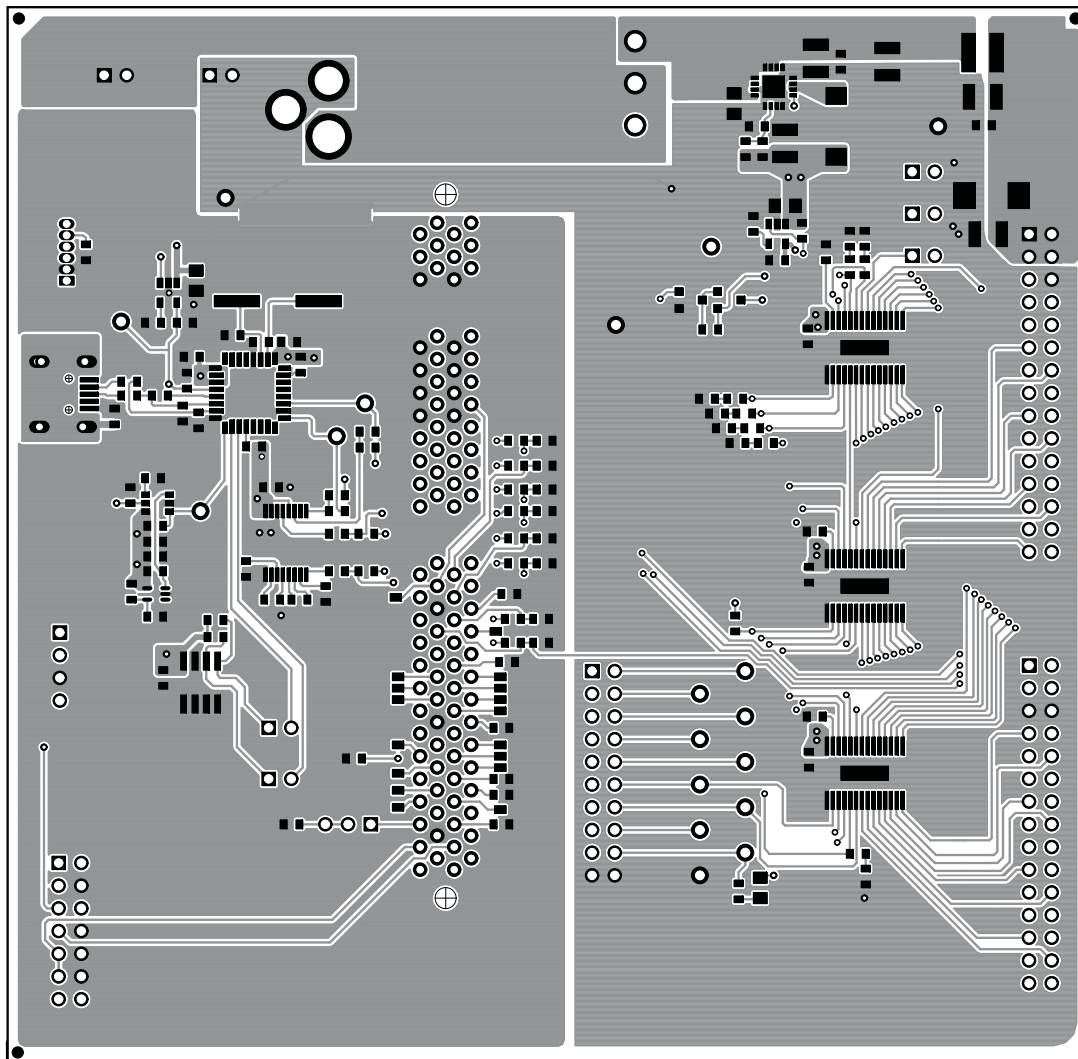


Figure 18. HPA358A Top Layer

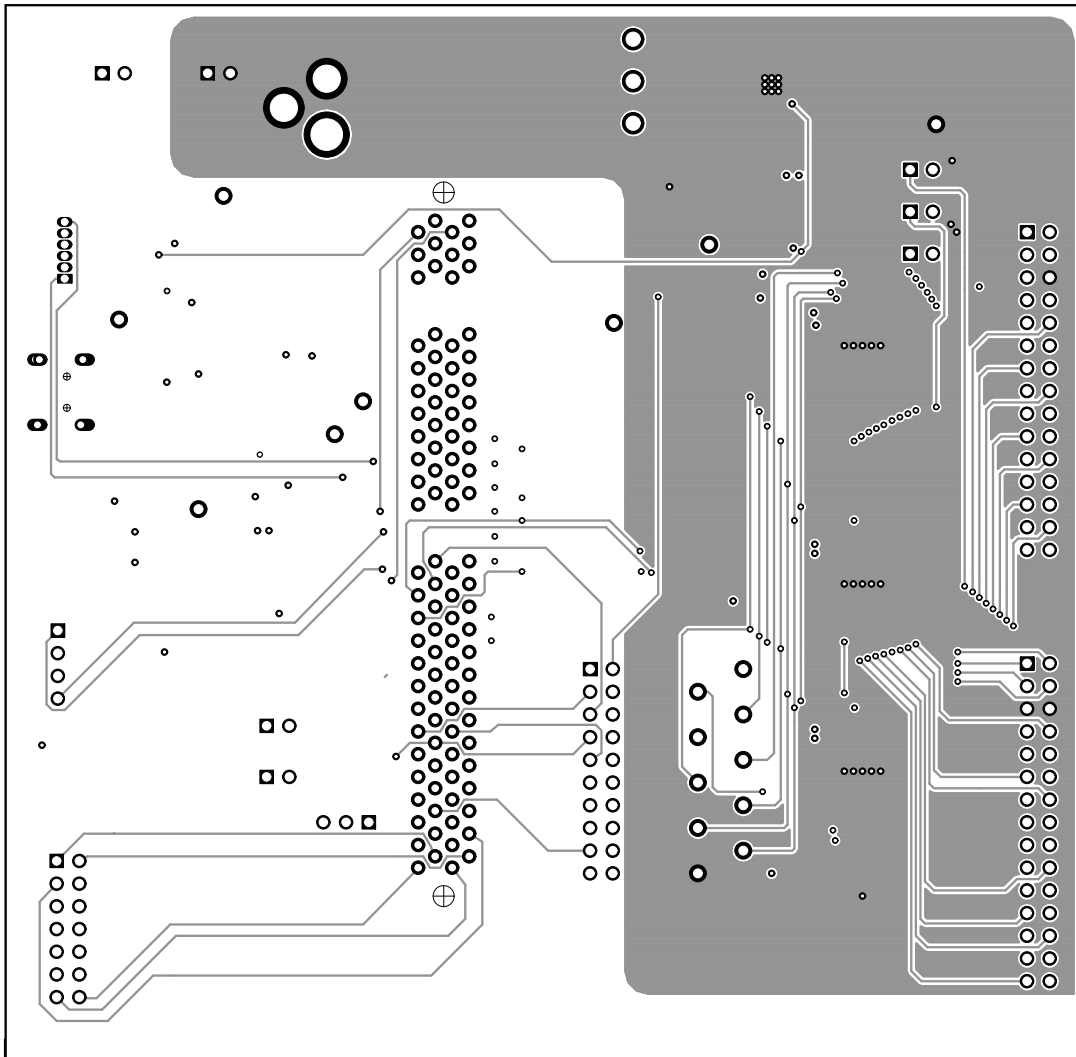


Figure 19. HPA358A Layer 2

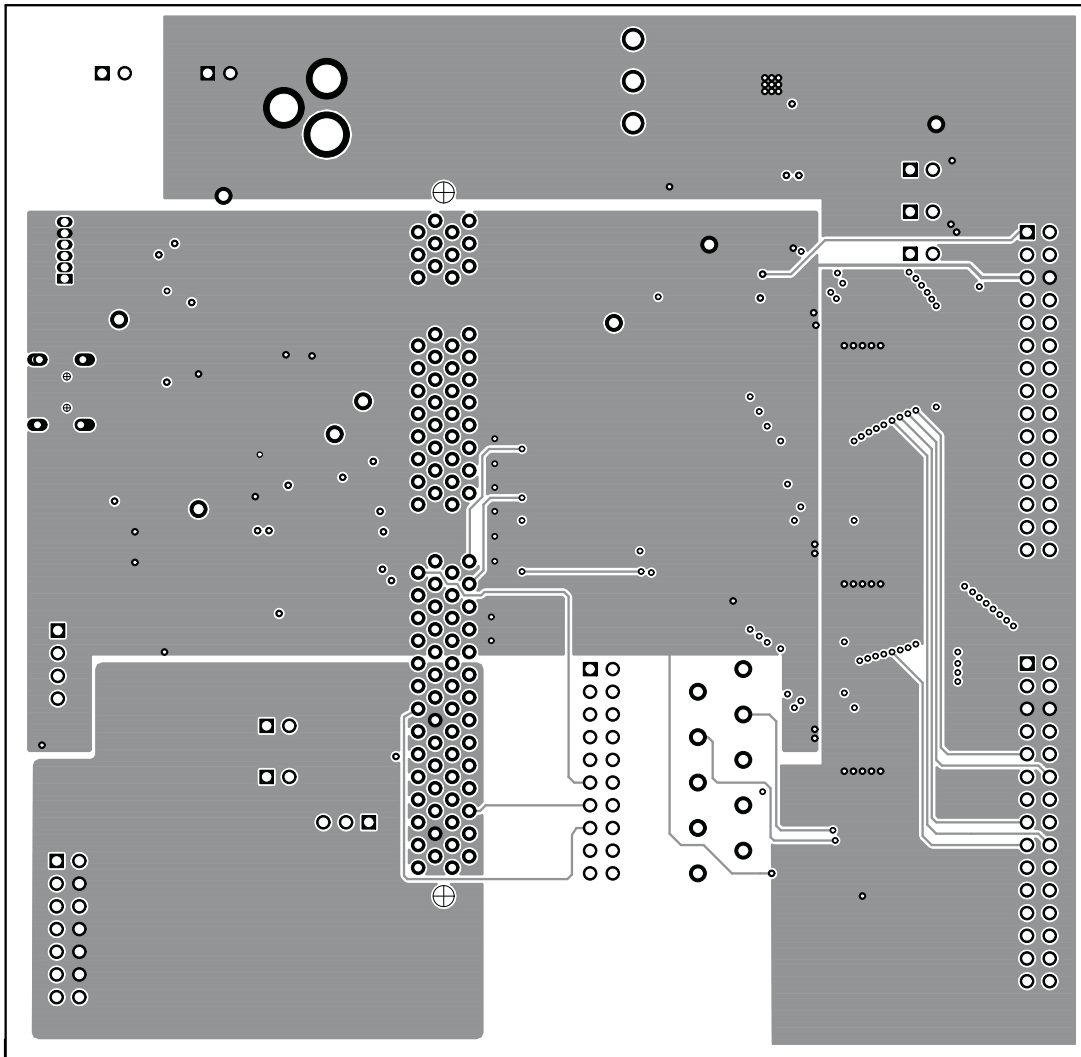
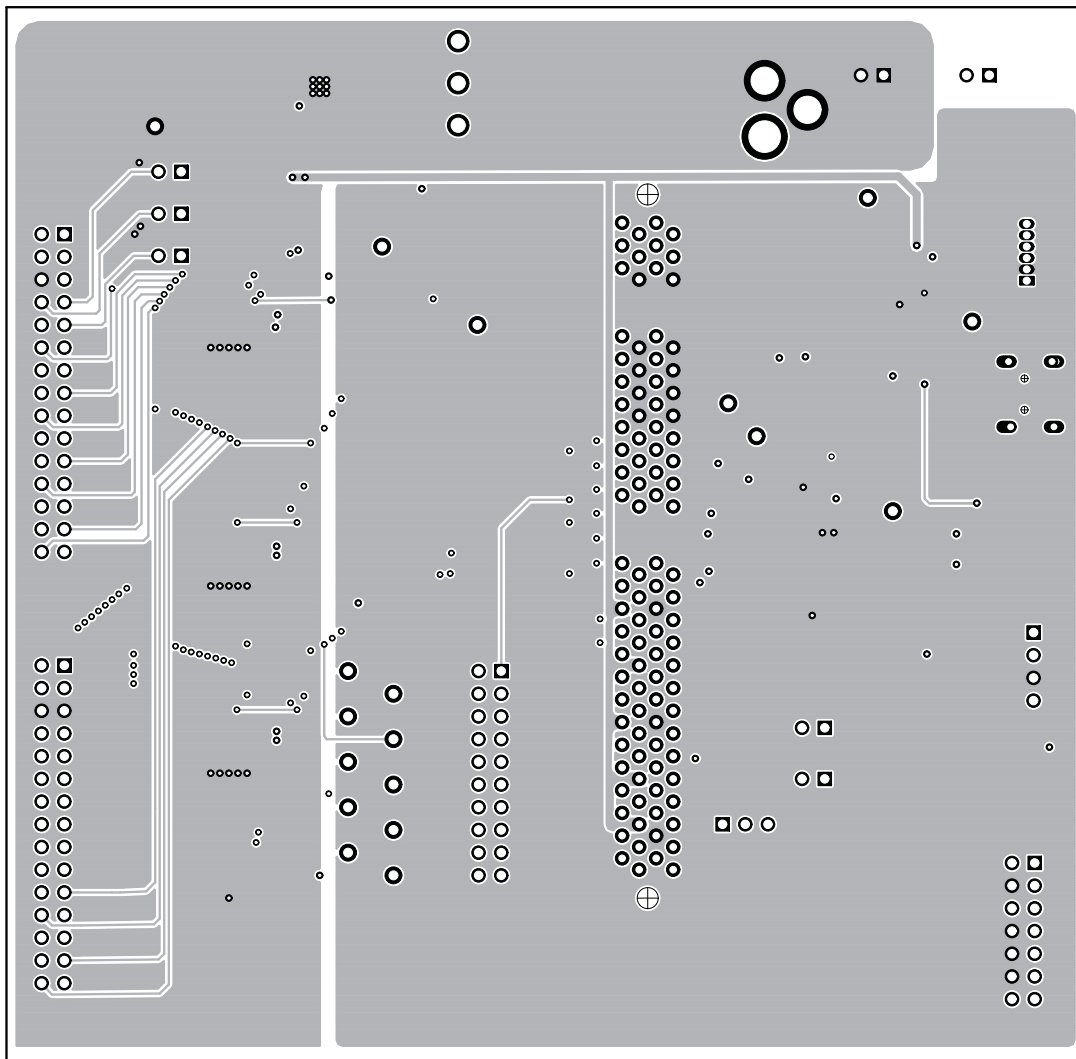


Figure 20. HPA358A Layer 3


Figure 21. HPA358A Bottom Layer Routing

4.3 Bill of Materials

Table 2. HPA357A Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
3	C1, C6, C7	0.01 μ F	Capacitor, Ceramic, 50V, X7R, 10%	0603	C1608X7R1H103K	TDK
3	C2, C3, C4	10 μ F	Capacitor, Ceramic, 25V, X5R, 10%	1206	GRM31CR61E106KA12L	Murata
1	C5	15 μ F	Capacitor, POSCAP, 25V, 90m Ω , 20%	7343(D)	20TQC15M	Sanyo
1	C8	0.1 μ F	Capacitor, Ceramic, 16V, X7R, 10%	0603	Std	Std
0	C9, C10	Open	Capacitor, Ceramic, 16V, X7R, 10%	0603	Std	Std
16	D0A–D15A	Q65110A4184	Diode, LED, 20mA, Common Anode	0.118 × 0.134	Q65110A4184	Osram
16	D0B–D15B	LST676-Q1R2-1	Diode, LED, red 12V, 30mA	PLCC-2	LST676-Q1R2-1	Osram
0	D16, D17	Open	Diode, Schottky, 0.5A, 30V	SOD-123	MBR0530T	On Semi
2	J1, J2	PPTC152LJBN-RC	Header, female, 2x15-pin, .100 inch, RA	0.500 X 1.520 inch	PPTC152LJBN-RC	Sullins
2	Q1, Q4	Si2303CDS	MOSFET, Pch, -30V, 1.64A, 190m Ω	SOT23	Si2303CDS	Vishay
2	Q3, Q6	Si2302CDS	MOSFET, Nch, 20V, 2.6A, 57m Ω	SOT23	Si2302CDS	Vishay

Table 2. HPA357A Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
2	Q2, Q5	Si2316BDS	MOSFET N-CH 30V 4.5A, 50 mΩ	SOT23	Si2316BDS	Vishay
2	R2, R6	10	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R3, R4	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	R1, R5	1.00K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	U1	SN74LVC2G86DCU	IC, Dual 2-Input Exclusive OR-Gate	VSSOP8	SN74LVC2G86DCU	TI
1	-		PCB	2.5 × 2.65 × 0.062"	HPA357	Any

- Notes: 1. These assemblies are ESD sensitive, ESD precautions shall be observed.
 2. These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.
 3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.
 4. Ref designators marked with an asterisk (***) cannot be substituted.
 All other components can be substituted with equivalent MFG's components.

Table 3. HPA358A Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
9	C1, C7, C21, C24, C27, C29, C32, C34, C35	0.01μF	Capacitor, Ceramic, 50V, X7R, 20%	0603	GRM188R71H103MA	Murata
2	C2, C4	22pF	Capacitor, Ceramic, 50V, COG, 5%	0603	GRM1885C1H220JA	Murata
4	C20, C22, C23, C48	10μF	Capacitor, Ceramic, 25V, X5R, 10%	1210	GRM31CR61E106KA12L	Murata
1	C25	1.0μF	Capacitor, Ceramic, 25V, X5R, 20%	0805	GRM216R61E105KA	Murata
1	C26	10pF	Capacitor, Ceramic, 50V, COG, 5%	0603	C1608C0G1H100DB	TDK
1	C28	22 μF	Capacitor, Ceramic, 16V, X7R, 20%	1210	C3225X7R1C226M	TDK
16	C3, C5, C9, C10–C19, C38, C39, C40	0.1μF	Capacitor, Ceramic, 6.3V, X7R, 10%	0603	GRM188R70J104KA	Murata
2	C30, C31	2.2μF	Capacitor, Ceramic, 6.3V, X5R, 10%	0805	C2012X5R0J225KT	TDK
1	C33	4700pF	Capacitor, Ceramic, 16V, X7R, 10%	0603	GRM188R71C472KA	Murata
2	C36, C37	2.2 μF	Capacitor, Ceramic, 6.3V, X5R, 10%	0603	C3216X5R0J105KT	TDK
0	C6, C8, C41–C47	Open	Capacitor, Ceramic, 6.3V, X7R, 10%	0603	Std	Std
1	C49	15uF	Capacitor, POSCAP, 25V, 90 mΩ, 20%	7343(D)	25TQC15M	Sanyo
1	D1	SML-LXT0805SRW-TR	Diode, LED, Red, 100 mA	0805	SML-LXT0805SRW-TR	Lumex
1	FB1	74279266	Bead, SMD Ferrite, 100 MHz Max. 200mA, ±25%	0603	74279266	WE
1	J1	UX60-MB-5S8	Connector, Recpt, USB-B, Mini, 5-pins, SMT	0.354 × 0.303 Inches	UX60-MB-5S8	Hiroise
2	J10, J11	PTC30DBAN	Header, Male 2x15-pin, 100mil spacing (36-pin strip), Right-Angle	0.100 inch × 15 × 2	PEC30DBAN	Sullins
0	J2	Open	Header, 1x6-pin, 50mil spacing	1.000 x 0.085 inch	850-106-10-S-RA	Millmax
0	J3	Open	Header, Male 4-pin, 100mil spacing, (36-pin strip)	0.100 inch × 4	PTC36SAAN	Sullins
1	J4	87630-1001	Connector, PCI Card, 100-pin 1.27 mm pitch	0.300 × 3.850 inch	87630-1001	Molex
1	J5	PTC36DAAN	Header, 2x7 pin, 100mil spacing (36 pin strip)	0.100 inch × 2 × 7	PTC36DAAN	
2	J6, J7	PTC36SAAN	Header, 2-pin, 100mil spacing, (36-pin strip)	0.100 inch × 2	PTC36SAAN	Sullins
1	J8	RAPC 712	Connector, Pin dia.2.5mm, DC Jack,	0.57 × 0.35 inch	RAPC 712	Switchcraft
1	J9	PTC36DAAN	Header, Male 2x10-pin, 100mil spacing (36-pin strip)	0.100 inch × 10 × 2	PTC36DAAN	Sullins
1	JP1	PTC36SAAN	Header, 3-pin, 100mil spacing, (36-pin strip)	0.100 inch × 3	PTC36SAAN	Sullins
5	JP2 - JP6	PTC36SAAN	Header, 2-pin, 100mil spacing, (36-pin strip)	0.100 inch × 2	PTC36SAAN	Sullins
1	L1	2.2μH	Inductor, SMT, 2.7A, 70 mΩ	0.153 × 0.153 inch	LPS4018-222ML	Coilcraft

Table 3. HPA358A Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
1	L2	6.8μH	Inductor, SMT, 1.6A, 49.2 mΩ	0.276 sq	SLF7032T-6R8M1R6	TDK
1	Q1	Si2302ADS	MOSFET, N-ch, 20V, 2.4A, 0.085 mΩ	SOT23	Si2302ADS	Vishay
1	Q2	SI2303CDS	MOSFET, Pch, -30V, 1.64A	SOT-23	SI2303BDS	Vishay
2	R1, R2	33	Resistor, Chip, 1/16W, 0.1%	0603	Std	Std
15	R4, R7, R17, R19, R21, R23, R24, R26, R28, R31, R35, R36, R40, R42, R54	10.0K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	R10, R11, R13, R15, R16, R18, R20, R22, R25, R27, R29, R30, R32, R33, R45, R47, R48, R49, R51, R52, R53	Open	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R3	1.50K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R34	2.70K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R37	316k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R38	110k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R39	14.7K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
3	R43, R44, R46	2.43k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
3	R5, R6, R41	1.00K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R50	121	Resistor, Chip, 1/16W, 1%	0603	Std	Std
4	R8, R9, R12, R14	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	S1	CS12ANW03	Switch, SPDT, Miniature Slide, 3A 125VAC	0.276 × 0.551 inch	CS12ANW03	NKK
14	TP1, TP2, TP6–TP8, TP10–TP1 8	5000	Test Point, Red, Thru Hole Color Keyed	0.100 × 0.100 inch	5000	Keystone
4	TP3–TP5, TP9	5001	Test Point, Black, Thru Hole Color Keyed	0.100 × 0.100 inch	5001	Keystone
1	U1	AT24C512BN-SH25-T	IC, 512K, Serial EEPROM	SO-8	AT24C512BN-SH25-T	Atmel
1	U2	TUSB3410IVF	IC, USB to Serial Port Controller	PQFP32	TUSB3410IVF	TI
1	U3	TRS3221ECDB	IC, RS-232 Transceivers with AutoShutdown	SSOP-16	TRS3221ECDB	TI
1	U4	TPS62110RSA	IC, Synchronous Step-Down Converter, 17V, 1.2A	QFN-16	TPS62110RSA	TI
1	U5	TPS3803-01DCK	IC, Voltage Supervisor, 3.3 Volts,	SOP-5 (DCK)	TPS3803-01DCK	TI
1	U6	TPS73018DBV	IC, Cap-Free NMOS, 150mA LDO Regulator With Reverse Current Protection	SOT23-5	TPS73018DBV	TI
1	U7	TPS73033DBV	IC, Cap-Free NMOS, 150mA LDO Regulator With Reverse Current Protection	SOT23-5	TPS73033DBV	TI
1	U8	TPS3808G18DBV	IC, Low Quiescent Current, Programmable 1.8 V, Delay Time: 1.25ms to 10s	SOT23-6	TPS3808G18DBV	TI
3	U9, U10, U11	TLC5944PWP	IC, 16 Channels 12bits PWM LED Driver with 6bits Dot Correction	PWP-28	TLC5944PWP	TI
1	Y1	ABLS-12.000Mhz-B2-T	Crystal, Controlled Oscillators	0.150 x 0.528 inch	ABLS-12.000Mhz-B2-T	ABRACON
14	--		Shunt, 100-mil, Black	0.100	929950-00	3M
1	--		PCB	4.65 x 4.75 × 0.062"	HPA358	Any
4	--	2566	Bumper, rubber		2566	SPC Tech

Table 3. HPA358A Bill of Materials (continued)

Count	RefDes	Value	Description	Size	Part Number	MFR
1	--		LED board		HPA357	TI
1	See Note 6		'F2808 DSP Control Card		TMDSCNCD2808	TI

- Notes:
1. These assemblies are ESD sensitive, ESD precautions shall be observed.
 2. These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable.
 3. These assemblies must comply with workmanship standards IPC-A-610 Class 2.
 4. Ref designators marked with an asterisk (***) cannot be substituted.
All other components can be substituted with equivalent MFG's components.
 5. Install rubber feet at bottom corners of assembled PCB after final wash.
 6. DSP Control card will be supplied by TI.
 7. **U1 will be programmed after assembly. See test procedure for programming instructions.**

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